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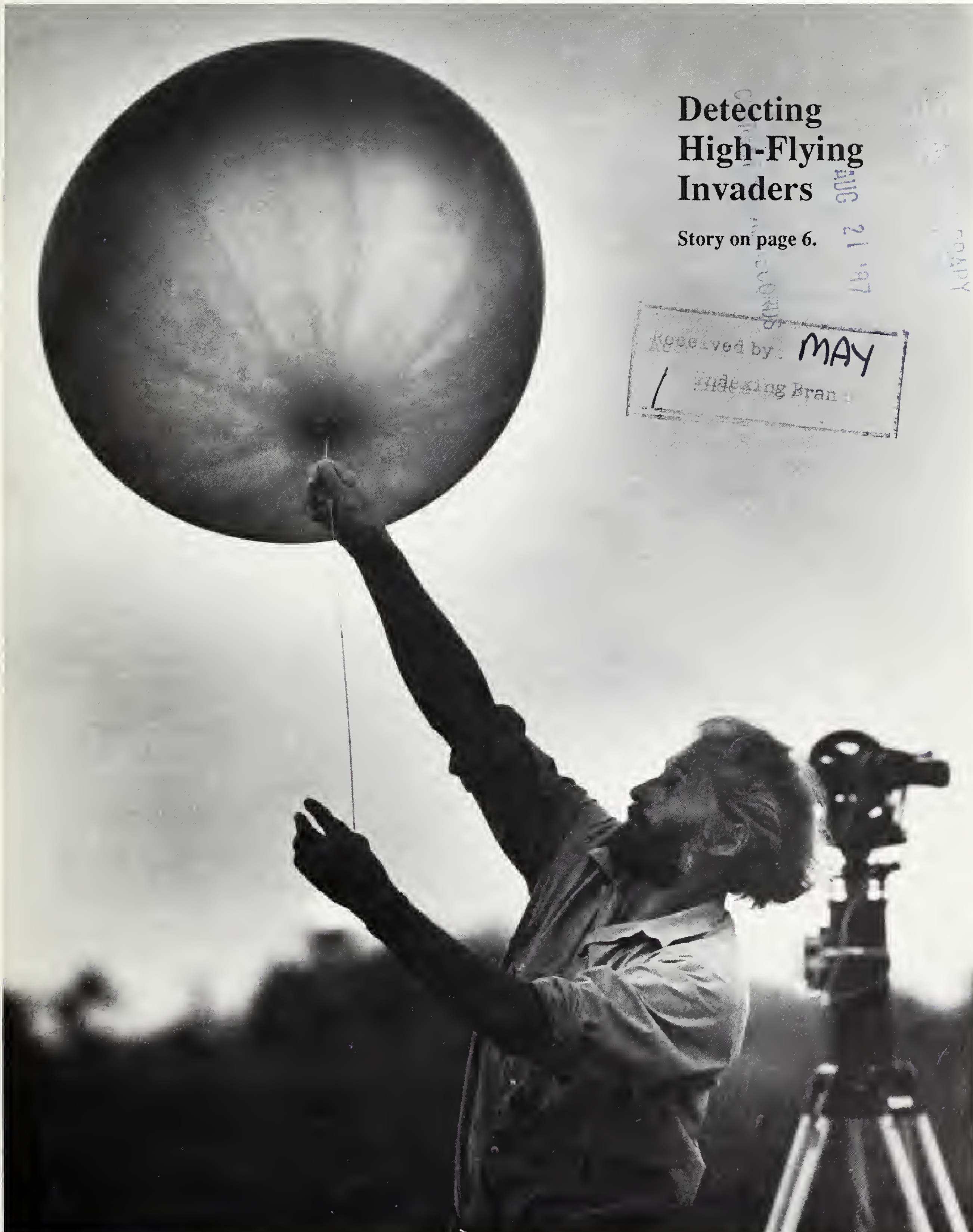

Detecting High-Flying Invaders

Story on page 6.

Strategic Controls Possible for Migratory Insects?

Insect migration is a major mystery in nature that we, as entomologists, must solve before we can deal effectively with most of our economically devastating insect pests. But understanding the migratory behavior of certain insects may not be enough. Indeed, we may have to change some of our basic ideas on pest control.

Through the years, scientists, agricultural planners, and farmers have developed a concept of pest management that is fundamentally defensive: we monitor pest conditions and establish economic thresholds or economic injury levels as the basis for applying pesticides. In essence, we willingly forfeit a portion of our crops to insects until they reach a certain population level or destroy a designated percentage of the crop, and then we grudgingly yield potential profits to the pests as we try to suppress them after they are entrenched in large numbers. Even then, we often experience additional crop damage because of miscalculations or our inability to achieve absolute control.

Perhaps, as an alternative to this defensive strategy, we should attack migratory insect pests at strategic times and places before they force us to defend our crops on a field-by-field, crop-by-crop basis. Such an offensive strategy would require more knowledge about insect migration.

Much of our present entomological data on insect movement could be correctly labeled as speculative and circumstantial. However, we are adding valuable knowledge through other sciences. Meteorological studies, for example, show how prevailing winds provide a strong air-transport system for migrating insects. And radar provides data on time, height, speed, and duration of insect flight. The combined evidence certainly leads to a conclusion that an effective pest management plan must consider the points of origin for highly mobile pest species.

Philosophically, regionwide pest management programs that result in less contamination of the environment through reduced use of pesticides ought to be preferred over current field-by-field, crop-by-crop strategies.

But going from a defensive strategy to an offensive one is more easily said than done. The technology required for a regionwide offensive against insect populations demands thoroughness and precision in its application. And the organization, financing, and execution will create special problems.

One of the biggest obstacles to adopting an offensive strategy against migrating insects will be the costs and difficulties involved in demonstrating that such a strategy will work. Many uncontrollable variables influence results of pest management trials, especially when experiments are undertaken on a small scale and during a short period. Those who question the feasibility of regionwide management stress the need for more information on the biology, ecology, behavior, and population dynamics of a species before large-scale management programs are tried.

But ecological studies in a small area over a short time may lead to wrong conclusions, especially if highly mobile pests or beneficial insects are involved. Pilot programs may be the only way to determine the wisdom of regionwide offensives. Such programs, if undertaken, must approximate the conditions that would occur regionwide. Only then, assuming the pilot program is successful, are the scientific, administrative, farming, political, and taxpaying communities likely to decide the time is right.

Complications associated with the regionwide management of insect pests are directly related to their numbers and their situations in time, space, and ecological niche. For example, efforts to manage corn insects in Iowa are simpler in relation to the number of species, time of occurrence, continuity of space, and diversity of ecological niches than similar efforts in the southern states.

Opponents of regionwide insect management say it is prohibitively expensive and scientifically unsound or technically too difficult to achieve. Those who favor the approach counter that regionwide management of some species of pests has resulted in monumental savings—and that research to implement the same management concept on other important species should be enhanced. Both sides agree, however, that migration is a major limiting factor to insect control that must be more thoroughly understood.

Alton N. Sparks
Leader, Insect Migration Research Team
USDA-ARS Georgia Coastal Plains Research Station
Tifton, GA

Agricultural Research

Cover: On the Mexico-U.S. border near Weslaco, TX, a weather balloon is released as part of a study on the migratory behavior of a major corn and cotton pest. This research could lead to more efficient control programs and an early warning system that alerts farmers to when and where infestations are most likely to occur. Article on page 6. Photo: Jack Dykinga (0687X597-17)

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Fruits and Vegetables Kept Fresh With Vitamin C Compounds

Vitamin C derivatives and other compounds prevent browning of cut apples in laboratory tests up to 48 hours and may be alternatives to sulfites for keeping salad-bar-style fruits and vegetables fresh, Agricultural Research Service scientists report.

"We think further studies will show that these compounds prevent browning for at least several days under commercial conditions," says chemist Kevin B. Hicks, leader of a research team at the Eastern Regional Research Center in Philadelphia, PA. "There is industry interest in working with us to test the new uses of these compounds."

Dipping apple slices in either of two classes of compounds closely related to vitamin C—ascorbic acid-2-phosphates and ascorbic acid-6-fatty acid esters—was most effective and prevented browning for up to 48 hours, according to preliminary results of research done in cooperation with scientists at Kansas State University.

The compounds worked on Winesap and Red Delicious apples, Granny Smith apple juice, and potatoes. Further studies may be done with cauliflower, mushrooms, lettuce, and other vegetables and fruits.

"We expect that these compounds will be safe and not affect taste," Hicks says, "but some will require Food and Drug Administration approval before use on food."

Fresh fruits and vegetables begin to turn brown once they are cut, sliced, or peeled. "Exposure to air helps an enzyme, polyphenol oxidase, react with polyphenols, natural chemicals inside these foods," says Gerald M. Sapers, a food technologist who developed the procedures to evaluate these compounds.

Sulfites were the most effective compounds for slowing down this reaction, Sapers says, but the FDA banned them last July for use on raw fruits and vegetables. "Ordinary vitamin C can be used but is effective for only a short time," he says. "The compounds we studied are far more effective than that."

The vitamin C (ascorbic acid) derivatives also controlled browning when mixed with cinnamic acid, beta-cyclodextrin, or a commercial inorganic phosphate compound.

Some of the compounds studied are already used in Japan for various foods, and one of them, ascorbyl palmitate, is used in the United States to preserve fats and oils. ARS is applying for a patent on their use as antibrowning agents.—By **Sean Adams,** ARS.

Kevin B. Hicks and Gerald M. Sapers are in USDA-ARS Plant Science Research, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118. ♦

Artificial Gene Aids Study of Oilseed Crops

Segments of DNA have been joined together by Agricultural Research Service scientists to make a synthetic plant gene. The new gene carries the "blueprint" for a key protein needed for soybeans and other oilseed plants to produce oil.

Going a step further, the scientists have successfully inserted the new gene into a common bacterium *(Escherichia coli).* Once in the bacterium's genetic makeup, the gene directs production of acyl carrier protein. In plants, this protein is needed for several steps in the synthesis of fatty acids that are components of cell membranes and of oils stored in plant seeds.

"Now enough of the protein can be made and purified to thoroughly study plant fatty acid synthesis," says biochemist John B. Ohlrogge, who headed a research team investigating fatty acids when he was employed at the ARS Northern Regional Research Center in Peoria, IL. Ohlrogge is continuing studies on the protein at Michigan State University in research funded through a USDA competitive grant.

Forming the synthetic gene for acyl carrier protein was made easier by a new laboratory instrument called a DNA synthesizer to produce nucleotides—DNA fragments—from simpler organic chemicals. Team member Phillip D. Beremand, a biochemist, constructed the gene by using enzymes to link together 16 of these fragments.

In theory, any gene that might be found in nature can be constructed in the laboratory. In natural genes, as in synthetic ones, building blocks—nucleic acids—are joined in a sequence that serves as a language. Through a series of steps, this nucleic acid language is translated to specify the amino acid sequence of proteins that a plant produces.

"In medical research, making genes chemically outside of living cells is becoming routine," Beremand says, "We applied the technology in a long-range quest toward increasing the commercial value of oilseed crops."

It's too early to tell whether this research may help scientists develop genetically engineered oilseed crops that produce higher yields or more healthful vegetable oils.—By **Ben Hardin,** ARS.

John B. Ohlrogge is at the Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312. Phillip D. Beremand is at the USDA-ARS Northern Regional Research Center, 1815 North University St., Peoria, IL 61604. ♦

Scientists Replace Soybean's "Turned Off" Genes

Genetic engineering—inserting beneficial genes into cells—hasn't been practical for soybeans because scientists couldn't get the altered cells to grow into whole plants. Now researchers are a step nearer that goal.

Somehow, a soybean cell's own genes for root and shoot development

seem to "turn off" in the lab, so Agricultural Research Service scientists in Beltsville, MD, are using a tumor-causing microbe to insert a new root gene into the cells.

"Without roots and shoots you obviously have no plant, and if you can't get a plant back, there's no point in genetic engineering," says plant physiologist Lowell D. Owens.

For some plants—like alfalfa, tobacco, and petunias—scientists can just add synthetic hormones, and roots and shoots develop.

With soybeans this doesn't work.

Owens and geneticist Ann C. Smigocki used *Agrobacterium tumefaciens,* a soil organism, to do their transferring for them. *A. tumefaciens* is no stranger to gene transfer. It infects a plant by actually inserting genes for both root and shoot formation into the same cells. In nature, a plant tumor forms from the conflicting instructions given by these genes.

But in the laboratory, Owens and Smigocki infected cells with an *A. tumefaciens* in which the gene for shoot development was inactivated. The resulting root growth proved the technique was workable.

But when they tried doing the reverse to get shoots—using *A. tumefaciens* in which the root gene was inactivated—it didn't work. The problem, they figured, could be that the part of a gene that tells it how much to "turn on" (called its promoter) isn't strong enough in the bacterium's shooting gene. So they removed the gene, took off the weak promoter and put on a stronger one. Then they designed two different ways of getting the "fixed" gene back into soybean cells: Either put the gene back into *A. tumefaciens* and have it insert the gene, or use electric shocks to do the inserting.

They are waiting to see if the gene's stronger promoters help it induce soybeans to make shoots.—By **Jessica Morrison,** ARS.

Lowell D. Owens is at the USDA-ARS Tissue Culture and Molecular Biology Laboratory, Room 116, Bldg. 011A, BARC-West, Beltsville, MD 20705. ♦

TIM McCABE

Soybean cells in dish at left have grown roots after a soil organism, *Agrobacterium tumefaciens,* inserted root-producing genes into them. Without added genes, soybean cells grow into unorganized clumps (right). (0687X531-9)

Berry Fungus Tricks Wild Bees

A fungus that attacks blueberries and huckleberries makes plant leaves look, smell, and taste like flowers—to some bees, at least.

And that's just the way the fungus likes it. The fungus, which causes mummy-berry disease, uses this trick to get its spores spread from plant to plant, says microbiologist Lekh Batra, of the USDA Agricultural Research Service in Beltsville, MD.

The phenomenon, called floral mimicry, was discovered by Batra and his wife Suzanne, an entomologist also with ARS.

The fungus, which can destroy over three-fourths of the crop in affected blueberry fields, makes infected leaves seem like flowers to bees by reflecting ultraviolet light and exuding sugars—things flowers do.

"A bee comes along, 'thinks' the leaf is a flower and lands on it to get the sugar. Instead, she gets fungus spores all over her tongue and legs," says Suzanne Batra. "When she flies to the next real flower, she spreads the fungus."

Called *Monilinia vaccinii-corymbosi*, this fungus robs fruit of their sugars, making them tasteless, woody-textured, and dried out. Hence the name mummy-berry disease.

Urea controls the disease, but serious infections need additional treatment with a fungicide, says Lekh Batra.

The Batras point out that their discovery doesn't mean farmers should worry about honey bees spreading the disease. They don't seem to be fooled by this fungus. In tests over 7 years, the Batras didn't see honey bees fall for the fake flowers once, even though they were in nearby fields.—By **Jessica Morrison,** ARS.

Lekh Batra is at the USDA-ARS Microbiology and Plant Pathology Laboratory, Room 253, Bldg. 011A, BARC-West, Beltsville, MD 20705. Suzanne W.T. Batra is at the USDA-ARS Systematic Entomology Laboratory, Bldg. 476, BARC-East, Beltsville, MD 20705. ♦

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Migration Team Tracks Night Flyers

JACK DYKINGA

ARS engineer Wayne Wolf (right) and visiting radar expert Joe Riley of the British Tropical Development and Research Institute study layers of cruising corn earworm moths on the screen of a radar unit. (0687X594-30)

JACK DYKINGA

Joe Riley adjusts the dish of the ground-based radar unit located near the Mexican border. (0687X596-5)

They travel mostly by night, taking off from farms in south Texas and northeast Mexico and riding warm winds north to targets hundreds of miles away. A special kind of radar has found them flying a few thousand feet above ground. They come each year, billions of them, and in 1986 they hit one of the largest industries in America with $1.5 billion in losses and protection costs.

So far, they haven't been stopped.

They are *Heliothis zea,* or corn earworms—a species of moth that invades corn and cotton fields (known then as cotton bollworms) throughout the Texas High Plains, Oklahoma, Louisiana, Arkansas, and the Mississippi Delta.

"We have evidence," says Alton N. Sparks of USDA's Agricultural Research Service, "that these insects are highly mobile, that the 500,000 acres of field corn produced in the lower Rio Grande Valley are a major source of their early season migrations, and that these migrations eventually cover and infest a pretty wide stretch of America's corn and cotton belts."

Sparks, an entomologist, leads an Insect Migration Research Team which

During one 2-week period in 1985, an estimated 6.5 billion corn earworm moths left the lower Rio Grande Valley for points north.

has been studying corn earworm populations for the past four springs along both the U.S. and Mexican sides of the Rio Grand near Weslaco, TX. Headquartered at the ARS Insect Behavior Laboratory in Tifton, GA, the team includes Sparks, two other entomologists, a meteorologist, and two agricultural engineers. Cooperating with the team is a group of scientists from the Mexican government's INIA (Instituto Nacional de Investigaciones Agricolas). The team has also been accompanied this year by visiting scientists from England and Australia.

"Documenting the migratory behavior of insects," Sparks says, "could lead to more efficient control programs and an early warning system that alerts farmers to when and where infestations are most likely to occur."

The scientist believes that farmers might be forfeiting more than necessary in the way of potential profits when they allow invading insects to infest crops to designated levels and then try to control them by spraying on a field-by-field,

JACK DYKINGA

Left: Before they take off into the night sky, agricultural engineer Wayne Wolf (right) and pilot Rene Davis check out their airborne radar. They will measure how long moths remain aloft and how their population densities decrease as they head downwind from infested fields. (0687X594-14)

Left, below: Meteorologist John Westbrook uses a theodolite to track a weather balloon's trajectory. (0687X596-7)

JACK DYKINGA

crop-by-crop basis. The data he's been getting in the lower Rio Grande Valley, he says, may support a more effective and less costly strategy: Attack a pest like the corn earworm at its lowest population level before it increases and starts spreading over a wider area.

Out in the cornfields, Sparks and team entomologists Sammy D. Pair and Jimmy R. Raulston check the soil for corn earworm pupae in order to estimate the number of moths that may be produced.

"Our surveys show that at least 70 percent of the field corn plants in this region will have an earworm larva feeding on soft kernels," Sparks says. "And under some conditions, that figure can rise to nearly 100 percent."

After the larvae mature in 2 to 4 weeks, they leave the ear, drop to the ground, and tunnel in to pupate. About 15 days later, they emerge from the soil as moths.

"We estimate their numbers to be as high as 25,000 or more per acre," says Sparks, who theorizes that the emergent moths embark on a migratory flight because the cornfields are no longer a suitable host—either the plants have been harvested, or the kernels have matured and dried.

To determine how many moths actually leave the Rio Grande Valley for more favorable habitats to the north, the scientists use a narrow-beam radar that can spot a single, 1-inch moth flying over a mile away.

"We're perfecting our equipment so that one day we'll be able to electronically sort and count all the different kinds of insects in flight," says team engineer Wayne W. Wolf. "Right now, the radar cannot distinguish between specific insects, but it can estimate total numbers in the air."

Depending on their numbers, size, and brightness, the blips on the radar scope can represent just a few insects or several thousand. During periods of heavy migration, Wolf and fellow engineer Kenneth Beerwinkle have tracked as many as 50,000 insects per hour and 16 million in the space of a mile.

Most of the moths take off at dusk and then, before sunup, drop out of the air currents and land (on corn and cotton fields) to feed and breed.

A second radar, this one airborne, measures how long the moths fly and how much the moth density decreases downwind from the source fields.

When radar readings indicate a high density of insects, an aircraft fitted with large nets is dispatched to collect samples in order to determine how many of the insects being tracked are actually corn earworm moths.

The team also deploys weather balloons which enable meteorologist John K. Westbrook to construct a detailed profile of the atmospheric environment the moths are flying in. Air temperature, humidity, and air pressure

JACK DYKINGA

JACK DYKINGA

Above: Using infrared night-vision goggles, entomologist Jimmy Raulston studies flight pattern of a corn earworm moth attracted to a pheromone-loaded trap set up in a Mexican cornfield. (0687X592-16)

Left: An entomologist with Mexico's Instituto Nacional de Investigaciones Agricolas, Jesus Loera, (right) and ARS scientist Alton Sparks (center) inspect a white corn ear for insect damage. A Mexican farmer looks on. (0687X596-28)

as well as windspeed and direction are recorded and correlated with the moth flight patterns.

"These insects cruise in layers anywhere from 500 to 5,000 feet above ground," says Westbrook, "depending on all these conditions."

When the wind is favorable, he adds, the moths can travel as far as 200 miles in 5 to 10 hours.

During a 2-week period in the spring of 1985, Sparks and his research team estimated that 6.5 billion moths left the valley for points north. In 1986, nematode infestations (which killed the corn earworm larvae) and rainy weather helped reduce the count to about 3 billion. Although the figures for 1987 aren't final, rainy weather may have again depressed the number of moths leaving the valley.

And how can these travels be stopped? "The best option," Sparks suggests, "would be the timely application of control measures at the source—right where the problem begins, while it's still concentrated in a small area."

That, of course, would require the participation of Mexico as well as the United States. Such cooperative efforts at insect control have met with success before—most notably in the screwworm eradication program.

"We still have to verify that this region is truly a major source of corn earworm infestations to the north," cautions Sparks. "If we do, I'm sure that

JACK DYKINGA

Entomologist Sammy Pair inspects a corn earworm moth retrieved from a trap. (0687X590-32)

something can be worked out to the benefit of both countries."

In addition to tracking corn earworm moths, the Insect Migration Research Team is documenting the number of earworm moths produced on the Texas High Plains to see if there is a return north-to-south migration from that region back to Mexico in the fall.

The team is also studying *Spodoptera frugiperda*, the fall armyworm. These moths fly northward each spring from southern Florida, the only east coast state where they can survive the winter, to lay eggs in grain and forage crops in southeastern states and northward along the east coast into Canada.—By **Steve Miller**, ARS. **Betty Solomon** (retired) contributed to this article.

Alton N. Sparks, Sammy D. Pair, John K. Westbrook, and Wayne W. Wolf are in USDA-ARS Insect Migration/Dispersal Research, Georgia Coastal Plains Experiment Station, P.O. Box 748, Tifton, GA 31793. Jimmy R. Raulston is in USDA-ARS Subtropical Crop Insect Research, 509 West 4th St., Weslaco, TX 78596. Kenneth Beerwinkle is in USDA-ARS Pest Control Engineering Research, Agricultural Engineering Building, Texas A&M University, College Station, TX 77843. ♦

Action Sites Best Place To Stop Corn Borers

Corn growers can cut back on the areas sprayed for European corn borers by as much as 85 percent by treating only the grassy areas in and around cornfields, says an Agricultural Research Service scientist in Ankeny, IA. Studies there show that the best time to kill these pests is when they gather in grass at night to drink dew and to mate.

Corn borers' natural predators also frequent the grassy areas, which entomologist William B. Showers calls action sites. But Showers says the best predators survived when exposed to some insecticides that kill the borer.

In a 2-year study at the Corn Insects Research Laboratory, Ankeny, IA, Showers and Iowa State University graduate student Fred Whitford sprayed insecticides containing carbaryl and fuel oil, or fenvalerate, along cornfield borders. They found that if insecticides are applied at mating time, most of the female borers die before they can return to the cornfield to lay their eggs.

The only problem to this control strategy is if a whole field is weedy. "Then we're back to treating the whole field and not just grassy areas left to control erosion and the areas around the edges," Showers says.

European corn borer moth, *Ostrinia nubilalis*. (0687X663-29A)

Treating the adult borer at this vulnerable stage of its life cycle in an open area might prove more beneficial than trying to treat larvae developing from eggs already deposited in a field, he says.

In the Midwest, adult moths breed primarily in smooth bromegrass in May and June, then switch their mating grounds in July and August as giant and green foxtail become available.

"You need to apply insecticides to field borders and the grassy runoff areas once to kill spring moths after they fly out to their mating grounds," Showers says. This generation has overwintered in the cornfield as larvae. Three more treatments, one in late July and two at about 8-day intervals in early August, are needed for the more numerous summer moths.

Growers usually apply insecticides to about 4 million of the over 70 million acres of feed corn grown each year. Damage from the borer and the cost of controls are estimated at about $37 million.

During the study, Showers and coworkers took a census of the ground-dwelling insects living in 12 of the action site plots. The 27,497 specimens collected consisted of about 100 species. In the collection were two beetle species (*Pterostichus chalcites* and *Harpalus pennsylvanicus*) that appear to be predators of European corn borer. They also prey on such other pests of corn as the black cutworm, armyworm, and stalk borer.—By **Betty Solomon** (retired), ARS.

William B. Showers is in USDA-ARS Corn Insects Research, Iowa State University Research Farm, Box 45B, Ankeny, IA 50021. ♦

Wild Bees Make Money Not Honey

Although still considered a fledgling industry, today's wild bee business has made a lot of progress since it got its start at the Pollinating Insect Biology Laboratory in Logan, UT, about 1950.

In a cooperative effort with state entomologists, USDA Agricultural Research Service scientists there began testing the ability of alkali bees and other wild bees to pollinate alfalfa—a major source of livestock feed.

"Horn-faced bees are excellent pollinators in humid regions of the eastern United States, where the climate is similar to that of their native Japan."

Suzanne W.T. Batra, ARS entomologist, Beltsville, MD

BOB BJORK

As word of this research spread, people began digging alkali bee larvae out of nests in the ground and selling them to pollinate alfalfa grown for seed in the Pacific Northwest. More recent studies at Logan and university experiment stations in the West have led to alfalfa being pollinated by another species of wild bee, the alfalfa leafcutter. It has largely replaced alkali bees—and honey bees—as the dominant pollinator of alfalfa grown for seed.

Without pollination, many plants fail to produce fruit or seeds. Perhaps half the total U.S. food supply depends directly or indirectly on pollination by honey bees. But wild bees—those that don't make honey—are the best pollinators.

They may also someday replace or at least supplement honey bees on crops other than alfalfa, particularly tree fruits and nuts.

But the shift to wild bees isn't likely to happen without a lot of help from entrepreneurs such as Greg Dickman in Auburn, IN.

Dickman's company, Orchard Bees, Inc., imported 10,000 horn-faced wild bees *(Osmia cornifrons)* from Japan last year. Dickman also designed and developed an inexpensive, disposable plastic nest that he hopes will eventually be used by beekeepers worldwide to raise several species of wild bees.

Dickman learned about the nesting needs of horn-faced bees while visiting ARS entomologist Suzanne W.T. Batra at her Beltsville, MD, lab in 1984. Dickman got his start in wild bees there and at the Logan lab, learning how to tell various wild bee species apart, how to manage them as pollinators, and how to raise them. He also learned how to reduce losses from insect predators and parasites in wild bee nests.

"The Japanese have used horn-faced bees to commercially pollinate apples and plums since the 1940's," says Batra, a world authority on this species. "These gentle bees are excellent pollinators in humid regions of the eastern United States, where the climate is similar to that of their native Japan. They can pollinate up to 2,500 flowers a day and survive winter temperatures as low as -5°F."

"Wild bees are prodigious pollinators," says ARS entomologist Frank D.

TIM McCABE

Above: Nesting tube used by *Osmia lignaria* has been cut in half to reveal a pollen and nectar plug with attached bee egg (left). A mud cap separates each egg chamber. (0587X486-12)

Left: Horn-faced bee, *Osmia cornifrons*. (0587X452-7)

Right: Near Logan, UT, entomologist Philip Torchio (right) and apple grower John Schoonmaker inspect the nesting tubes of *Osmia lignaria*. ARS is studying the pollination and nesting productivity of wild bees in Schoonmaker's orchard. (0587X479-29)

TIM McCABE

Parker in Logan. "It takes 80,000 honey bees to pollinate a 1-acre fruit orchard, but only 250 blue orchard bees *(Osmia lignaria)*. Individual bees from two strains of blue orchard bees—one found east of the Rockies and the other in the drier western states—can pollinate as many as 2,600 flowers a day."

That's because the blue orchard bees land directly on the sexual mechanisms—the anthers and stigma—of a flower, making pollination very likely. For the honey bee it's more haphazard. It lands on a side panel of the flower and inserts its tongue between the anthers to remove the nectar, often without transferring pollen to the stigma.

"Wild bees placed in a fruit orchard live only about 4 weeks," says Parker, research leader of the Logan lab—the only federal lab exclusively rearing and researching wild bees. "But in that time, working from early morning to dusk, they can reproduce enough to double or triple their population each year. We would be overrun with them if they occurred naturally in orchards. However, they usually nest in the mountains—in old beetle burrows and nail holes in dead aspens and other trees."

In the orchards, growers or beekeepers give the bees similar nesting sites by drilling 3/8-inch holes into blocks of wood. Throughout her short lifespan, the female blue orchard bee deposits about 30 to 35 eggs—along with loaves made of nectar and millions of pollen grains from several hundred flowers.

Within a few days, the eggs hatch into larvae, which spend the next few weeks feeding on the nectar and pollen loaves. After this, the larvae spin cocoons and enter a resting state until late summer. As the days grow colder and shorter, the larvae—still snug in their nests—change into adult bees that will emerge the following spring when the weather warms.

"It takes 80,000 honey bees to pollinate a 1-acre fruit orchard, but only 250 blue orchard bees."

Frank D. Parker, ARS entomologist, Logan, UT

The time that they emerge can be controlled by keeping the nests in a cold place until the bees are needed for pollination. When trees are starting to blossom, a fruit grower places the nests in the middle of an orchard. Within hours, the warmth of the sun triggers the bees' biological clock. They begin to emerge and forage for pollen. And the cycle repeats itself.

Some wild bees could completely replace honey bees for pollinating specific crops. With California almonds, for example, entomologist Philip F. Torchio, also at the Logan lab, estimates it would only take about 5 years of concerted effort by California beekeepers and growers to boost current populations of wild *Osmia cornuta* bees—imported from Europe—to the 300 million needed to pollinate the entire crop. "That's far less than 1 percent of the 60 billion honey bees now needed to do the job," he says.

Wild bees are also safer to use, says Torchio. Some orchard owners are afraid to handle honey bees because of the likelihood of getting stung. But most wild bees are extremely docile. "You practically have to pinch them to get stung."

In spite of the advantages of wild bees for certain crops, honey bees are still needed for the bulk of pollination chores.

They are the only ones that make honey on a commercial scale, valued at over $100 million last year. And their economic worth hardly stops with honey. Pollination fees and sales of beeswax provide sizable returns to honey beekeepers.

But America's favorite pollinators face two serious threats: Africanized bees—steadily advancing northward from Latin America and due to arrive in the southern United States about 1989 or 1990—and infestation by two kinds of parasitic mites.

Honey bees are vulnerable to interbreeding with Africanized bees because they are different strains of the same species *(Apis mellifera).* Africanized bees take over any honey bee hive they encounter and pass on their aggressive, stinging behavior. They also produce less honey.

Wild bees, on the other hand, are not related to African bees and do not mate with them.

Mites also threaten domestic honey bees. These parasites move easily among the highly social honey bees, which almost continuously touch each other, but have no effect on wild bees—probably because wild bee adults live alone and because mites are generally specific to certain insect species.

One mite damages the trachea or breathing tubes of honey bees. Another mite—widespread in Europe and rapidly becoming a U.S. problem—causes birth defects in newly hatched honey bees. Afflicted bees are often born without wings or legs.

Using wild bees to pollinate crops has its problems, though. "The main stumbling block is getting enough bees," says Parker. "It could take 5 to 10 years of trapping and raising these bees to get enough to pollinate large orchards."

That is what Dickman and others face in getting their operations off the ground. Still, Parker believes the chances for success are excellent. "What we've got here is a new agribusiness—a 'bee broker': someone who buys and sells wild bees as if they were commodities or shares of stock. Their clients are farmers, orchard growers, and home gardeners—a potential market of 40 million people," he says.—By **Howard Sherman,** ARS.

Frank D. Parker and Philip F. Torchio are at the USDA-ARS Pollinating Insect Biology Laboratory, Room 261-BNR, UMC 5300, Utah State University, Logan, UT 84322. Suzanne W.T. Batra is at the USDA-ARS Systematic Entomology Laboratory, Bldg. 476, BARC-East, Beltsville, MD 20705.


BOB BJORK

In Auburn, Indiana, entrepreneur Greg Dickman videotapes his wild bees to help customers understand how the bees "work". (0587X454-13)


BOB BJORK

Dickman experiments with wild bee nests of his own design. Manufactured for him to exact dimensions, the nests are angled to protect the bees from rain. Dickman also hand-colors the tubes to determine nesting preferences. (0587X449-7)

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In the Works:

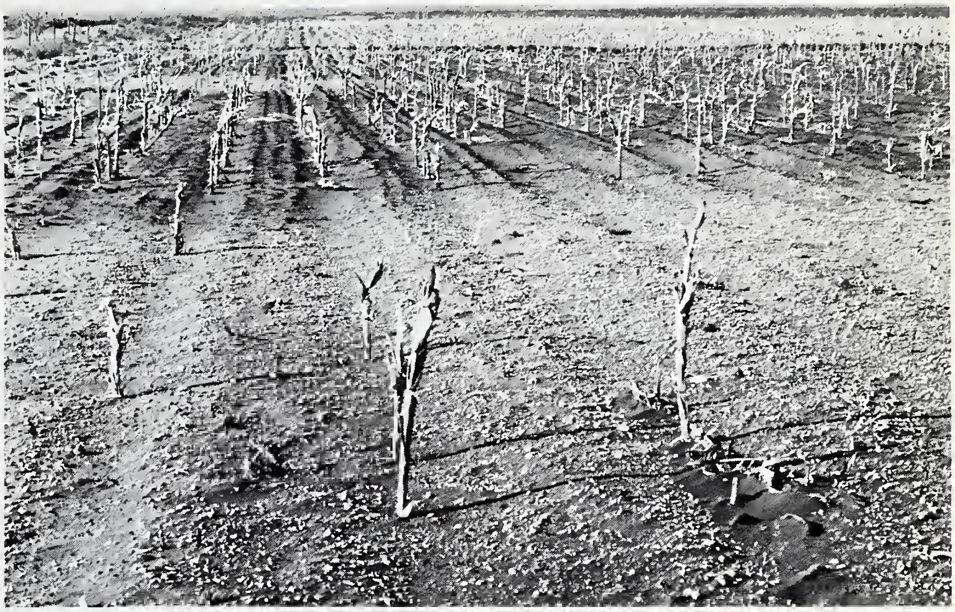
A New Way To Predict Wind Erosion

While not as severe or as visible as in the Dust Bowl days, U.S. soil is still blowing around, mostly inches above the ground rather than in dust clouds.

Not that the country is headed for another Dust Bowl. Far from it, thanks to modern soil and water conservation techniques now in use, many of them developed by USDA's Agricultural Research Service.

Yet wind is still a force to be reckoned with in cropland erosion. In the Great Plains last year, wind damaged 8.4 million acres of land, an area equivalent to half the size of the infamous Dust Bowl. Annually, wind-damaged land has averaged some 6.3 million acres since 1970, reports the USDA Soil Conservation Service (SCS).

In addition to damaging land, wind erosion last year destroyed 746,000 acres of crops or grass cover. Sand-laden wind traveling at ground level at speeds of up to 30 miles an hour or more literally sandblasts sorghum, wheat, and other crops.



Blowing topsoil can sandblast growing crops as happened in this Andrews County, TX, cornfield during the 1940's. (TEX-42,423)

Although wind erosion is very visible while in progress, its effects may be subtle, according to Leon Lyles, an ARS agricultural engineer in Manhattan, KS.

"It's difficult to decide whether the amount of erosion on a given field is excessive or not," says Lyles, who heads the ARS Wind Erosion Unit. Soil loss occurs gradually, and measuring it requires scientific techniques and equipment.

Until 3 years ago, no equipment existed to measure soil losses in the field. That's when Bill Fryrear, an ARS agricultural engineer at Big Spring, TX, designed samplers that collect dust as wind blows through them. Wind vanes at the tail end of each sampler keep the open ends of the samplers pointing into the wind. The pie-shaped samplers are placed at intervals from 6 to 20 inches above ground, swinging around a thin rod stuck in the ground.

Fryrear, soil scientist Ted Zobeck, and agronomist J.D. Bilbro are collecting field data with the samplers.

Because many studies have indicated at least 75 percent of wind-erodible particles never get airborne more than 8 inches, Fryrear and ARS wind engineer John E. Stout have recently built a ground-level sampler to collect eroding particles from the ground up to 8 inches. A test with both types of samplers during a small windstorm this past May confirmed results from earlier studies and also showed that 10 percent of blowing soil just rolls along the ground.

With data collected by these devices, scientists should be able to better estimate and manage wind erosion.

Currently, SCS estimates erosion by using the Wind Erosion Equation developed by ARS scientists in the mid-60's. In cooperation with SCS, Fryrear, Lyles, and colleagues are developing a new prediction model that will replace the present equation.

Computer simulations, coupled with new findings and adjustments for modern farming methods, make replacement of the equation desirable. The fact that the 1985 Farm Bill calls for determining farmer eligibility for federal subsidies based on erosion estimates makes a more accurate equation a must. Potentially, hundreds of millions of dollars of federal aid are at stake.

In the old equation, data about soil types is limited to the central plains states. Farmers in states outside the plains—such as Washington, Oregon, South Carolina, Maryland, and Michigan—also need data about wind erosion. "Accurate information is needed so that farmers anywhere in the country can make conservation decisions to reduce erosion," says Lyles.

"To estimate plant damage from one storm, we need to know what happens in a shorter time than the long-term averages provided by the old equation," Lyles says. "With the new wind erosion model, we'll be able to make erosion predictions for a month, a year, 50 years, or a single storm that may last 45 minutes or less."

"Rather than basing estimates on an average of 30 to 40 years' weather data and waiting for history to repeat itself, we'll have a more accurate, day-by-day, account of soil surface conditions," says Lyles.

The old Wind Erosion Equation will remain in place and be used until it can be replaced with the new model.—By **Linda Cooke**, ARS. **Don Comis**, ARS, contributed to this article. 100

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2-45

Individual Wrapping Holds Freshness Key //

Fruits and vegetables can stay fresh two to three times longer if they're wrapped immediately after harvest in plastic films that allow produce to breathe.

"Although the films look much like the clear plastic wrap you use at home for wrapping sandwiches or leftovers, that's where the similarity ends," says Roger E. Rij, a marketing specialist with USDA's Agricultural Research Service in Fresno, CA. "The films we use in our experiments have microscopic pores. This helps the fruit or vegetable take in some needed oxygen, get rid of excess carbon dioxide, or give off ethylene—a natural compound that could otherwise cause overripening."

Household wrap, in contrast, usually isn't porous and usually doesn't let gas flow in and out of the package, he says.

"Differences in the way each film is manufactured result in a different and characteristic pore or hole size throughout a particular film. The size of the hole affects the rate at which the molecules of a given gas can escape from or seep into the environment surrounding the wrapped fruit or vegetable," Rij explains. "This is because the molecules of one gas are a different size than those of another. We can experiment with a wide selection of films—each made with a different formula and different hole size—to get a film that helps set up the perfect microenvironment for each type of fruit or vegetable.

"Peaches and nectarines, for example, store best in an environment with 5 percent carbon dioxide, while broccoli responds better to 10 to 12 percent carbon dioxide. For the peaches and nectarines, we use a film that—by virtue of the size of the holes—tends to let carbon dioxide molecules escape out of the wrapped package. But for broccoli, we use a film with smaller pores to slow down the escape and keep the vegetable surrounded with more of this gas.

"Sometimes produce is wrapped in the back room of the supermarket—to make the food more attractive—but that's not what we're talking about," says Rij. "We mean wrapping in the packing shed right after it is picked."

Although the films aren't new, the test results from Rij and colleagues are. The researchers have shown which wraps work best with already proven storage methods. This is because simple refrigeration, or the more sophisticated "controlled atmosphere storage" (in which the mix of gases in storage rooms is carefully controlled), can significantly affect movement of the gases in or out of the film-wrapped package. Rij says shrink- or stretch-wrapping is "meant to enhance, not replace" these other types of storage.

The recent tests build on earlier successes, most notably those of ARS scientists in Florida and researchers in Israel who were able to preserve freshness and storage life of newly harvested grapefruit, lemons, and other citrus by wrapping them in plastic film. This work led to Rij's tests in which he used polyvinyl chloride films from Borden Chemical Co. to preserve individually wrapped bunches of broccoli and larger packs of six to eight peaches or nectarines. Rij says unwrapped broccoli normally keeps for only a week and a half or 2 weeks at the very most, while wrapped broccoli—with the right storage—"can now look and taste good for up to 3 weeks."

He cites these benefits. "Wrapping means that when you go to the grocery store, your favorite fresh fruits and vegetables might be available from U.S. growers anywhere from a few days to a few weeks longer than usual. And instead of being picked underripe—so that they won't deteriorate or rot before they're sold—they can be picked at the peak of perfection."

Film wrapping also opens new possibilities for exporting fruits to faraway markets now unavailable because produce loses its freshness, flavor, or color during the long journey.

Use of the wrap could be boosted by the recent development of new, faster, and more reliable equipment for automatically wrapping the produce.

Gene E. Lester, a plant physiologist in Weslaco, TX, has dramatically improved the shelflife of individually wrapped cantaloupes—an exceptionally perishable crop. The experiments were part of a long-range study on how fruit decays, and how techniques such as genetic engineering might someday be used to delay it.

TIM McCABE

At the Weslaco, TX, research facility, plant physiologist Gene Lester prepares cantaloupes for the shrink-wrap process. Following enclosure in the wrap, melons will travel by conveyer through an oven where the plastic is shrunk to a tight fit. (0387X172-12)

"Individually shrink-wrapped melons will last at least three times longer than unwrapped melons—and still have excellent quality, firmness, flavor, color, and sugar," Lester says.

Lester's films, made of a plastic known as polyolefin and manufactured by E.I. du Pont de Nemours & Co., trap moisture molecules—the key to preventing the melons from becoming shrunken and shriveled. Cantaloupe is mostly water and has a tremendously short shelflife; it usually lasts no more than 3 to 14 days after harvesting, he explains. But with wrapping and proper cold or controlled atmosphere storage, melons can last up to 40 days.

TECHNOLOGY

TIM McCABE

Cantaloupes stored without shrink-wrapping show clear signs of decay inside and out (right, center~~, and~~ bottom). Wrapped fruit, which was grown, harvested, and stored under the same conditions, remains fresh and tasty. (0387X169-29)

For growers in Texas, Arizona, and California—the states that produce the bulk of the nation's cantaloupes—the new research may open new markets. "We may be able to ship melons to Japan, an idea that was impractical before because cantaloupe is so perishable," says marketing specialist Thomas H. Camp of the Weslaco laboratory. "In Asia, U.S. melons are a delicacy and sell for $10 to $12 or more each. Melons could also be sold in gift packs at duty-free shops at U.S. airports or could be offered by shippers of specialty food gifts for delivery to customers in the United States and Canada."

The film that works so well for cantaloupe also keeps four other crops—tomatoes, green bell peppers, cucumbers, and eggplant—crisp and fresh. Agricultural marketing specialist Lawrence A. Risse in Orlando, FL, says refrigerated, shrink-wrapped tomatoes can last almost a month, while unwrapped tomatoes can become soft and mushy after 2 weeks. Unwrapped bell peppers are no good after 10 days at room temperature, while wrapped peppers—tasted 3 to 4 weeks after harvest—"will be as crisp and fresh as the day you picked them," he says. Results for cucumbers were similar. And wrapped eggplant lasts 2 weeks at room temperature, as compared to 1 week for its unwrapped counterpart.

Wrapping should cost only about 1 or 1-1/2 cents per piece once the production line is set up, Risse says. He notes that with peppers and cucumbers, there was sometimes a problem with decay organisms, which can flourish in the moisture-laden environment of the wrapped package. So he's currently experimenting with treatments to kill these microbes quickly, yet safely.

Some fruits simply don't benefit from wrapping. With mango and avocado, decay was so severe that "we've put the idea of using film for these crops on hold for now," says Donald H. Spalding, ARS plant pathologist at the Subtropical Horticulture Research Station in Miami.

But the experiments that did work out have attracted some interest. Kash, Inc., a California packer-shipper, has followed Roger Rij's research and is now wrapping small amounts of produce as an experiment. If this works out, their goal is to use ocean transport instead of faster but more expensive air freight to ship fruit to markets in Europe and the Far East. And NASA's Johnson Space Center in Houston is getting advice from Gene Lester in Weslaco on shrink-wrapping fruits and vegetables for space shuttle and space station astronauts.—By **Marcia Wood,** ARS. 100

Roger E. Rij is at the Horticultural Crops Research Laboratory, 2021 South Peach Ave., Fresno, CA 93727. Gene E. Lester and Thomas H. Camp are at the Subtropical Agriculture Research Laboratory, P.O. Box 267, Weslaco, TX 78596; Lawrence A. Risse is at the U.S. Horticultural Research Laboratory, 2120 Camden Rd., Orlando, FL 32803. ♦

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PATENTS

Low-Cal Sweeteners

Many sodas and candies are sweetened with high-fructose corn syrup made from glucose derived from cornstarch. This common glucose (D-glucose) is just one of many types of natural sugars called aldose sugars. Many of these could be used to produce rare or unavailable forms of ketose sugars that may be useful as low-calorie sweeteners or ingredients of pharmaceutical and other industrial products.

The problem is that the enzymes used by industry to turn glucose into fructose work only with D-glucose and not other natural aldose sugars.

This patented process solves the problem by using different catalysts that convert all types of aldose sugars into ketose forms.

It involves a chemical reaction between an aldose sugar and boric acid dissolved in water and mixed with an amine catalyst.

The process can also be used to convert so-called left-handed sugars like L-glucose into L-fructose, a sugar some claim is as sweet as natural fructose but has no calories.

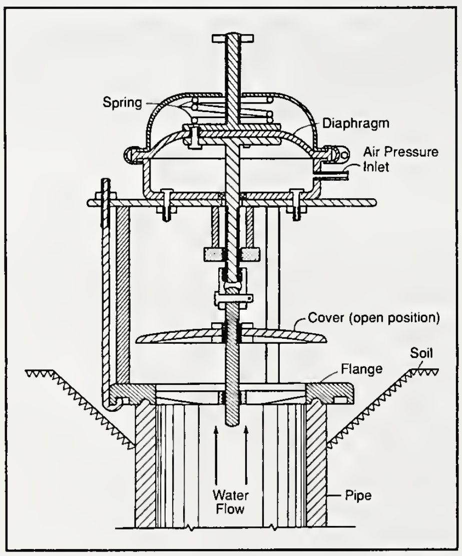
One caution, though. Products derived from the rare sugars have not yet been approved by the Food and Drug Administration for commercial use.

For technical information, contact Kevin B. Hicks, USDA-ARS Food Biochemistry Research, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118. *Patent No. 4,273,922, "Ketose Sugars From Aldose Sugars."* ♦

An Easy Way To Automate Irrigation Valves

This ingenious device readily converts several kinds of manual irrigation valves for automatic operation using compressed air controls.

Automating irrigation this way makes it easier for farmers to improve efficiency. And because it requires air pressure to keep valves open, any electrical or equipment failure automatically shuts the valves, preventing accidental releases of water common to nonpneumatic systems.



Retrofitted alfalfa valve

The new device clamps on to the top of an irrigation valve without any changes other than replacing the handle and threaded stem which are used to open and close the valve.

When pressurized air enters the chamber at the top of the upper shaft, a diaphragm compresses a spring, raising the shaft and turning the water on. When the air is vented from the chamber, the spring pushes the shafts down and stops the flow of water.

For technical information, contact Clayton H. Gibson or Ronald E. Yoder, USDA-ARS Irrigation and Drainage Research, 764 Horizon Dr., Suite 215, Grand Junction, CO 81506. *Patent Application Serial No. 06/892,006, "Retrofit Device for Alfalfa Valves."* ♦

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